MODULAR AVIONICS UPGRADE : THE COST EFFECTIVE SOLUTION TO ADAPT EXISTING FIGHTERS TO THE OPERATIONAL REQUIREMENTS OF TODAY'S BATTLEFIELD

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ABSTRACT

This paper presents already fielded implementations of an avionics upgrade package developed to offer a modular solution to a wide range of modern operational requirements. The *SAGEM SA* upgrade concept allows to match specifications ranging from basics performance enhancement, such as high accuracy navigation for low level flight, up to full muti-role capability with sophisticated air-to-surface weapon delivery and multi-target air-to-air fire control.

The upgraded system implements all state of art features available on the most recent fighters, particularly for pilot interface (HOTAS, glass cockpit, NVG compatibility, ...) as well as for system architecture (modular avionics, high level of redundancy and back-up modes, ADA HOL programming, object oriented software ...).

The presentation will describe how the most recent technologies can be inducted in older platforms more rapidly than on newly developed airframes, therefore ensuring that the most demanded operational requirements are fully satisfied. In particular, sensor technologies (pulse-Doppler Radar, thermal imaging and IRST ...) will be addressed, as well as smart weapons (guidance kits, advanced fire control software ...) which are driving factors for the overall accuracy for the success of the mission.

A special highlight will be given on ground support equipment and procedures both at operational and maintenance levels. These facilities include part-task trainers and mission planning systems to help the pilots optimize their missions ; in parallel an integrated logistic support is deployed to give all necessary tools to the maintenance crews.

INTRODUCTION

With close to twenty years of experience in fighter upgrade, in collaboration with the Air forces of various countries, SAGEM has been developing and validating an integrated modular avionics concept meeting a wide range of operational requirements of the armed forces and which can be easily installed in different older or recent operating platforms.

It took place naturally through an industrial approach in order to meet the operational performance requirements while minimizing the access cost to technology required to secure the performance. As a result of this approach, SAGEM defined a **system core: the Multifunction Navigation and Attack System (MNAS)** capable of gathering all the management and control functions of today's avionics, such as:

- system mode management (Navigation, Training, A/G Attack, A/A Interception, ...)
- armament units and EW equipment management
- optimal management of Pilot/NAS interface
- radar mode automatic management
- computation of fire control parameters (visual and hearing)
- computation of accurate navigation, guidance and flight control parameters, including sensor hybridisations (GPS, Radar, Laser Rangefinder, FLIR, etc.)

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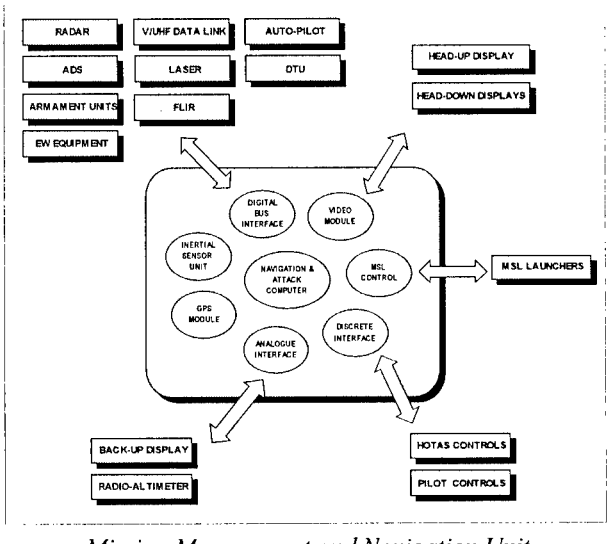
SAGEM INTEGRATED MODULAR AVIONICS APPROACH

The avionics system upgrade level can be evaluated, from the operational point of view, as the ability of the system to perform efficiently the mission for which it will be used. Given the great diversity of today's missions, the multi-role platforms are consequently the best operational solution for most of the armed forces. Today's combat aircraft has to be a polyvalent platform intended for upgrading.

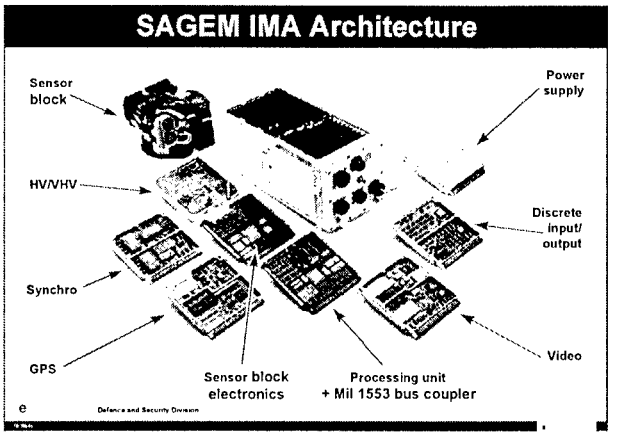
To upgrade a combat aircraft (old or new one) a modular and integrated logic is required in order to comply fully with the armed forces evolution requirements. In fact, according to today's economic requirements of the forces, the platforms which were initially designed and bought to perform a particular mission, will generally be modified or adapted to new missions which nature will be developed in accordance to the geopolitical situation of the countries involved. So, the initial operational requirements get more complicated and their time validity is reduced.

In order to meet this new requirement, the system architectures offered will have to be functionally open-ended and economically attractive: therefore, the Integrated Modular Avionics (IMA) concept is involved. This modular approach of SAGEM is considered as an original one because all the main management and control functions of the system are gathered in a single equipment (system core) with a standardized welcoming structure based on the inertial navigation system (INS).

In order to meet specific requirements, hardware and software system functions have been added to this core.



Mission Management and Navigation Unit



AVANTAGES OF THE SAGEM APPROACH

The navigation unit is usually used as a system sensor giving attitude and position data. Nevertheless, it is much more profitable to use it as a basic equipment for the MNAS development:

→ ***Optimal System Integration***

The whole management and control functions of the system are gathered in a single equipment entirely benefiting from the following hardware resources needed to operate:

- ❒ high-performance RISC computer used as a mission and navigation management system
- ❒ digital (ARINC 429, 1553B BUS, RS-422) and analog (Discrete, Synchro ...) interface modules
- ❒ symbol generator video module (HUD, MFD)
- ❒ an armament management module ("Store Management Module")
- ❒ a C/A or P(Y) GPS module

The origin of these modules can vary from one model to the other. They can be replaced easily for technology (for example, obsolescence of the components) as for functional reasons (to improve performances).

→ ***Higher performances***

As the main computer is the same for mission management and navigation, the delays for dating the parameters needed for ballistic calculations are reduced, thus providing an improved aiming accuracy.

→ ***A cost-effective solution***

As the number of equipment to be connected is lower, the cost of integrating the equipment into the aircraft is reduced as well. The aircraft wiring modifications are also reduced.

→ ***A reliable and upgradable solution***

As various electronic modules are gathered in only one equipment, with shared resources (power, mass

storage, CPU, etc.), this system is more reliable compared to a classical architecture.

Moreover, the reduction in the equipment number leads also to the aircraft digital bus load reduction thus making easier to integrate new external sensors.

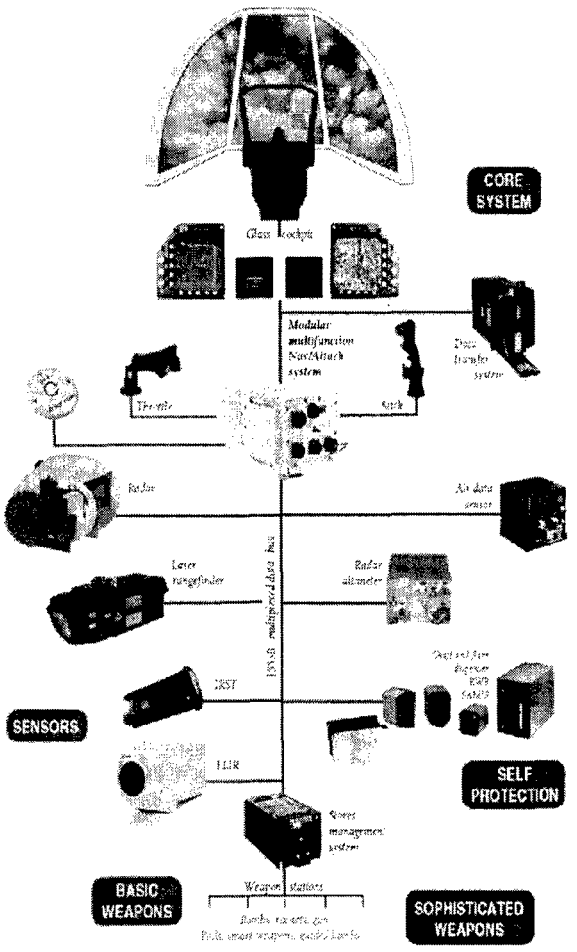
→ ***Easier maintenance operations***

The maintenance cost is also a key factor to select the right system architecture.

The reduction in the equipment number directly affects the maintenance cost by reducing as well the number of maintenance test benches.

SAGEM ARCHITECTURE EXAMPLE

As an example, a SAGEM integrated modular architecture is showed hereafter. The whole functions of the system have been centralized into a single equipment.



MANAGEMENT OF AN UPGRADE PROGRAMME

The IMA concept has a direct impact on the way to manage an upgrade programme. Generally, such programme can be made up of eight stages:

1- Detailed analysis of the operational need

According to the operational need, expressed first by the headquarters when applying to strategic options (armaments, Radar, EW Equipment, etc.) and then expressed by the pilots when applying to operational options (system interface), a relevant analysis stage is required in order to define the main upgrade axes while meeting the following requirements:

- ❒ cost-effective requirements (total budget)
- ❒ operational requirements (performances)
- ❒ aircraft requirements (mechanical loading, electric power, cooling environment, ...)
- ❒ customer requirements (logistic capacities)

The use of qualified technologies and integrated modular avionics (IMA) design is required so as to optimize the development cost and programme financial success by reducing the aircraft modifications and developments (hardware and software).

Defining a logistic support adapted to the customer requirements and capacities is also a deciding factor.

2- System design

The hardware design of the system has been simplified thanks to the integration of a modular avionics and the software design has been also simplified due to the operation of functional and qualified modules. However, with such an approach the system designer must think in terms of functional modules (hardware or software) and not in terms of equipment.

At the same time, an important work on the aircraft must be initialized at the beginning of the programme in order to identify as soon as possible all the aircraft requirements.

3- Software integration

This stage is dedicated to the integration and the validation of all software modules which have been gathered as single processing module. Specific software development and simulation tools have to be used at this stage to validate specific requirements (interface, timing, dynamic behaviour...)

4- System integration

Following the Software integration stage, all the functions and interfaces of the system have to be validated via a dedicated integrating test bench allowing to implement the real equipment as well as simulation models. This test bench is absolutely necessary to validate modules and to implement the system.

5- Integrating the equipment into the aircraft prototype model

The aim of this step is to integrate and validate the electrical and mechanical installations of the aircraft equipment and the specific part of the test instruments. It is also used to check the equipment environmental conditioning.

6- Ground and flight tests

The aim of this step is to verify the performances of the system and to prove to the customer that all the operational requirements have been fulfilled properly.

7- Preparing and starting production

In order to be successful, this preparation stage has to start during the modification of the prototype model so as to validate simultaneously the whole aircraft modification sheets (TCTO).

In order to reduce the costs, a partnership usually takes place with the customer for production (production of mechanical and electrical installation kits, equipment installation, etc.).

8- Integrated logistic support

The logistic support shall be defined according to the needs and capacities of the customer for the required levels (O, I and D'Levels). It generally includes the delivery of the spare equipment and test equipment, the training to maintenance, the maintenance documentation supply and, eventually the implementation of a local technical assistance team.

CONCLUSION

Due to the reduction of defense budgets, every aircraft manufacturer or system designer now understands that it is no longer possible to design complex systems by simply associating, as before, system function with an individual equipment. In order to satisfy the cost-effectivity, upgradability and accuracy needs of the air forces, integrated modular solutions are today's must.

Very early confronted with the market competition for military aircraft upgrades, SAGEM has developed an integrated modular core system implementing cost-reduction industrial processes, which can easily be tailored according to customers' requirements. This core system is based upon functional modules which are either developed by SAGEM or outsourced from specialised manufacturers. Today, this core system is in operation at the heart of several upgrade programmes.